# Dietary intake and cardiovascular risk in children and adolescents after cancer treatment

Marcela Barros Barbosa de Oliveira[1,2]  Ramara Kadija Fonseca Santos[2,3]  Marcelle Wanderley de Lacerda Melo[4]
Kiriaque Barra Ferreira Barbosa[1,3]  Liliane Viana Pires[1,3]

[1]Departamento de Nutrição, Centro de Ciências Biológicas e da Saúde, Universidade Federal de Sergipe – UFS. Aracaju/SE, Brasil.
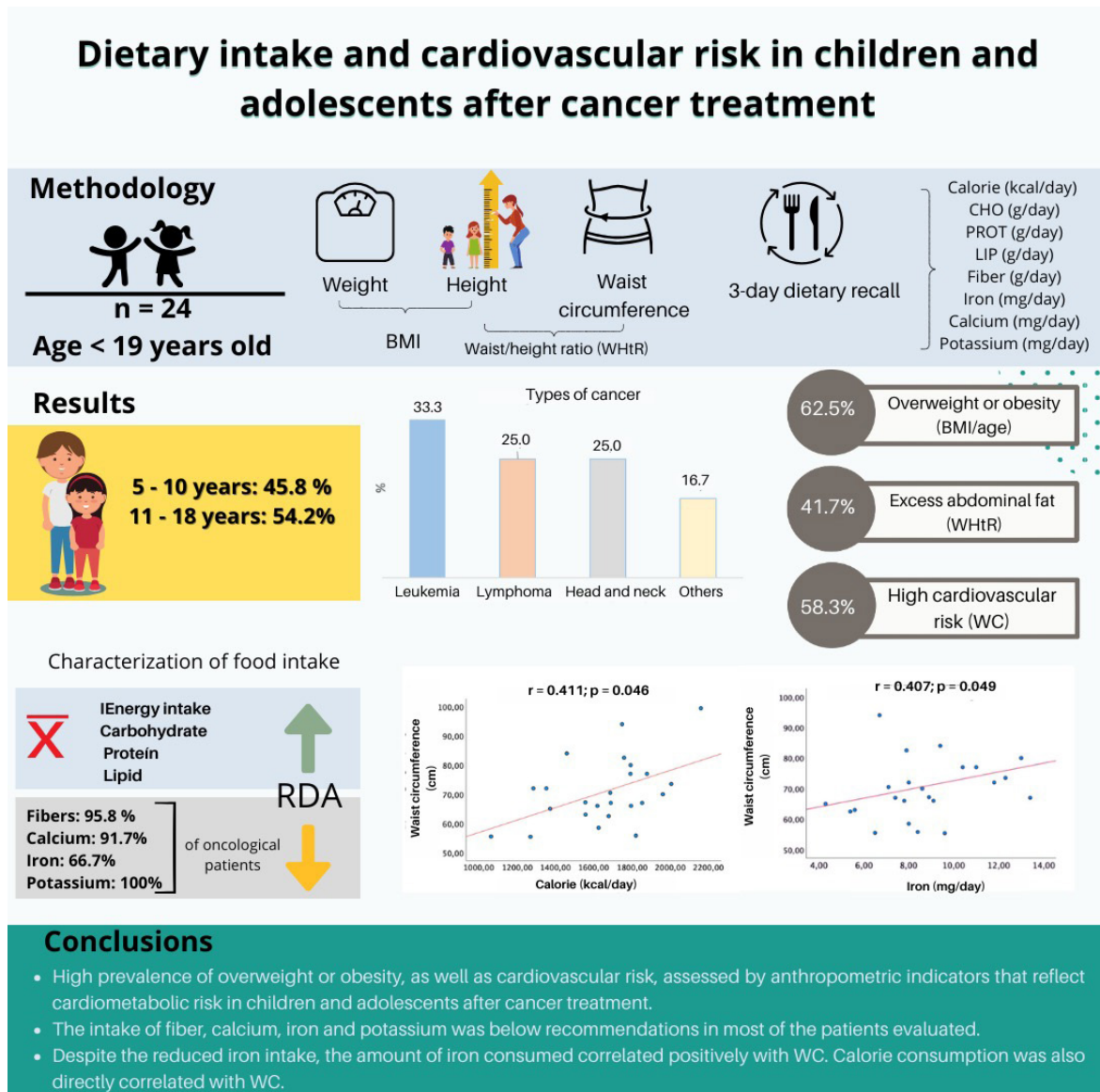[2]Programa de Pós-graduação em Ciências da Saúde, Universidade Federal de Sergipe – UFS. Aracaju/SE, Brasil.
[3]Programa de Pós-graduação em Ciências da Nutrição, Universidade Federal de Sergipe – UFS. São Cristóvão/SE, Brasil.
[4]Associação dos Voluntários a Serviço da Oncologia em Sergipe – AVOSOS. Aracaju/SE, Brasil.
E-mail: lvianapires@academico.ufs.br

**Graphic Abstract**



## Dietary intake and cardiovascular risk in children and adolescents after cancer treatment

**Methodology**

n = 24
Age < 19 years old

Weight — Height  BMI
Waist circumference  Waist/height ratio (WHtR)
3-day dietary recall

Calorie (kcal/day)
CHO (g/day)
PROT (g/day)
LIP (g/day)
Fiber (g/day)
Iron (mg/day)
Calcium (mg/day)
Potassium (mg/day)

**Results**

5 - 10 years: 45.8 %
11 - 18 years: 54.2%

Types of cancer
33.3 Leukemia
25.0 Lymphoma
25.0 Head and neck
16.7 Others

62.5% Overweight or obesity (BMI/age)
41.7% Excess abdominal fat (WHtR)
58.3% High cardiovascular risk (WC)

Characterization of food intake

IEnergy intake
Carbohydrate
Protein
Lipid
RDA

Fibers: 95.8 %
Calcium: 91.7%
Iron: 66.7%
Potassium: 100%
of oncological patients

r = 0.411; p = 0.046
Waist circumference (cm) vs Calorie (kcal/day)

r = 0.407; p = 0.049
Waist circumference (cm) vs Iron (mg/day)

**Conclusions**

- High prevalence of overweight or obesity, as well as cardiovascular risk, assessed by anthropometric indicators that reflect cardiometabolic risk in children and adolescents after cancer treatment.
- The intake of fiber, calcium, iron and potassium was below recommendations in most of the patients evaluated.
- Despite the reduced iron intake, the amount of iron consumed correlated positively with WC. Calorie consumption was also directly correlated with WC.

**Abstract**

New cancer treatments have increased the life expectancy of children and adolescents, however, they are associated with excess weight and consequently with cardiovascular risk. The objective of this study was to relate dietary intake, cancer remission time with anthropometric indices related to cardiovascular risk in children and adolescents after cancer treatment. A cross-sectional study was carried out with children and adolescents, both sexes, monitored by AVOSOS in the city of Aracaju/SE. The volunteers were evaluated regarding clinical and anthropometric aspects (weight, height, waist circumference [WC], body mass index and waist/height ratio) and food consumption using a 24-hour recall. Pearson or Spearman correlation tests were applied, with p<0.05 being significant. 24 individuals were evaluated (45.8% children and 54.2% adolescents), mean age of 11.6 ± 0.84 years and disease remission time of 26.2 months. The types of cancers reported were leukemia, head and neck, lymphoma and other types (33.3%, 25.0%, 25.0% and 16.7%, respectively). Excess weight/obesity, abdominal fat and increased risk for cardiovascular disease were observed in 62.5%, 41.7% and 58.3% of the sample. The majority of participants had insufficient intake of fiber (95.8%), calcium (91.7%), iron (66.7%) and potassium (100%). A positive correlation was observed between WC and calories consumed (r=0.411, p=0.046) and dietary iron (r=0.407, p=0.049). The other variables analyzed were not correlated. Children and adolescents who survive cancer have an increased cardiovascular risk and a positive correlation between WC and caloric intake and dietary iron.

**Keywords:** Nutritional Status. Anthropometry. Obesity. Children. Teenagers.

# INTRODUCTION

The survival rate of patients with childhood cancer has increased, according to data from the American Cancer Society, which show that 85% of patients with childhood cancer have a life expectancy of five years or more, a fact attributed to advances in disease treatment[1]. Despite the increase in life expectancy in children after cancer treatment, complications have been observed in this population, among which endocrine complications stand out, which contribute to the development of obesity and the consequent increase in the cardiovascular risk of children after cancer remission[2].

Post-cancer treatment complications vary depending on the therapy offered and the location of the tumor. In this sense, radiotherapy presents itself as a treatment with the greatest potential risk of contributing to the appearance of endocrine complications. For example, weight gain, increased waist circumference and Body Mass Index (BMI) have been observed in children and adolescents, accompanied by changes in the lipid profile and markers of glycemic control after six months of cancer treatment[3].

Furthermore, the treatment of cancers located in the central nervous system causes a reduction in the secretion of pituitary hormones, causing deficiencies in growth hormones (GH), luteinizing hormones (LH), and follicle-stimulating hormones (FSH), thyroid-stimulating hormone (TSH) and adrenocorticotropic hormone (ACTHD), which are associated with an increased risk of developing obesity, diabetes and precocious puberty in children after cancer treatment[2]. In addition to the effects of treatment and type of cancer, lifestyle, such as unhealthy food choices and a sedentary lifestyle, also contributes to obesity in childhood cancer survivors[4].

Therefore, this study sought to test the hypothesis that diet and cancer remission time are related to increased cardiovascular risk in children and adolescents post-treatment for the disease. Studies of this nature are necessary to better elucidate the factors that contribute to the increase in cardiovascular risk in this population. Therefore, our objective was to relate dietary intake, cancer remission time with anthropometric indices related to cardiovascular risk in children and adolescents after cancer treatment.

## METHODOLOGY

### Casuistry

A cross-sectional study was carried out, in a convenience sample composed of 24 individuals (children and adolescents) post-cancer treatment, of both sexes, accompanied by the Association of Volunteers at the Service of Oncology in Sergipe (AVOSOS) in the city from Aracaju/SE. Clinical, socioeconomic data, family history of chronic non-communicable diseases, use of medication, presence of associated diseases, practice of physical activity and time of disease remission were obtained, which was self-declared by parents or guardians regarding the last cycle of chemotherapy, the starting from the application of a previously structured form. Participants were also assessed regarding anthropometric characteristics (weight, height and waist circumference) and food intake.

Inclusion criteria were considered: being a resident of the state of Sergipe, being under 19 years old and being monitored for up to five years after remission of the disease. Patients who were using corticosteroids six months or less before the evaluation were excluded.

All those responsible were informed about the procedures to which they would be subjected and signed the Free and Informed Consent Form. This research was approved by the Research Ethics Committee of the Federal University of Sergipe – UFS under nº 1,058,904.

### Anthropometric assessment and prediction of cardiovascular risk

Weight and height values, waist circumference were obtained, and the Body Mass Index (BMI) was calculated. Weight, height and waist circumference (WC) values were obtained using the techniques recommended by the Manual of Guidelines for Collection and Analysis of anthropometric data in health services[5].

Data on weight, height, WC and BMI were used for nutritional diagnosis by calculating BMI/Age indexes (BMI/A)[6] and for assessing cardiovascular risk using the ratio of waist measurement to height (WHtR)[7,8].

They were considered overweight when the BMI/A ratio was above one standard deviation of the Z-score[6]. Abdominal obesity was considered when WC values were above 90 percent[9]. WHtR greater than or equal to 0.50 was considered excess abdominal fat and high metabolic and cardiovascular risk[7,8].

### Assessment of dietary intake

To assess dietary intake, the 24-hour dietary recall (24HR) was applied on three non-consecutive days, one day on the weekend, with those over 15 years of age, and with those responsible when the participants were under the age of 15 years.

The analysis of the foods consumed by the research participants was carried out using the NutWin software, from the IT Department of the Escola Paulista de Medicina/UNIFESP. The adequacy of the diet was carried out based on comparisons with the Dietary Reference Intakes proposed by the Institute of Medicine[10-13].

### Statistical analysis

Descriptive analysis of the data was carried out. Continuous data were presented as mean and standard deviation and categorical variables as absolute (n) and relative frequency (%). The Shapiro-Wilk test was applied to evaluate data distribution.

To evaluate the relationship between dietary intake, disease remission time, anthropo-

metric variables and cardiovascular risk predictor indices (WHtR and WC), Pearson and Spearman correlation tests were applied. The correlation was considered weak for r values between 0.10 and 0.29; r ≥ 0.30 to 0.49 moderate correlation and r ≥ 0.50 strong correlation[14].

The collected data were stored in a Microsoft Office Excel 2010 spreadsheet and evaluated using SPSS Software, version 28. P-value < 0.05 was considered significant.

## RESULTS

24 patients participated in this study with a mean age of 11.7 ± 0.8 years, of both sexes, with a predominance of females (54.2%). The majority of participants did not practice physical activity (58.3%) and had a family income between one and two minimum wages (75.0%). The average time of disease remission was 26.2 ± 16.6 months. The types of cancers reported were leukemia (33.3%), head and neck cancer (25.0%), lympho- ma (25.0%), and other cancers (16.7%).

Of the individuals evaluated, 62.5%, 41.7% and 58.3% were overweight or obese according to the BMI/age relationship, excess abdominal fat according to WHtR and high cardiovascular risk according to WC, respectively. Table 1 shows the socioeconomic and anthropometric characteristics of the children and adolescents evaluated.

**Table 1 -** Clinical, anthropometric and socioeconomic characteristics of children and adolescents post-cancer treatment (Aracaju-SE. 2015).

| Variable | N=24 |
| --- | --- |
| **Sex, n (%)** | |
| Male | 11 (45.8) |
| Female | 13 (54.2) |
| **Age (years)** | **11.6 ± 0.8¥** |
| 5 to 10 years old, n (%) | 11 (45.8) |
| 11 to 18 years old, n (%) | 13 (54.2) |
| **Physical activity, n (%)** | |
| Yes | 10 (41.7) |
| No | 14 (58.3) |
| **Family income, n (%)** | |
| 1 to 2 minimum wages | 18 (75.0) |
| > 2 minimum wages | 6 (25.0) |
| **Disease remission time (months)** | **26.2 ± 16.6¥** |
| 0 to 12 months, n (%) | 7 (29.2) |
| 13 to 36 months, n (%) | 12 (50.0) |
| 37 to 60 months, n (%) | 5 (20.8) |
| **Types of Cancer, n (%)** | |
| Leukemia | 8 (33.3) |
| Head and neck | 6 (25.0) |

| Variable | N=24 |
| --- | --- |
| Lymphoma | 6 (25.0) |
| Other types of cancer | 4 (16.7) |
| **Weight (kg)** | **45.1 ± 3.5¥** |
| Height (cm) | 139.8 ± 7.1¥ |
| Low height for age, n (%) | 7 (29.2) |
| Appropriate height for age, n (%) | 17 (70.8) |
| **WC (cm)** | **70.9 ± 2.3¥** |
| No cardiovascular risk, n (%) | 10 (41.7) |
| Risk associated with obesity, n (%) | 14 (58.3) |
| **WHtR, n (%)** | |
| No excess of abdominal fat | 14 (58.3) |
| Excess of abdominal fat | 10 (41.7) |
| **BMI (kg/m²) / age relation** | **21.1 ± 1.1¥** |
| Low weight, n (%) | 4 (16.7) |
| Appropriate, n (%) | 5 (20.8) |
| Overweight or obesity, n (%) | 15 (62.5) |

¥ Data presented as mean and standard deviation.
Data presented in absolute and relative frequency [n (%)].
Caption: BMI: Body Mass Index; WC: Waist Circumference, WHtR: waist/height ratio.

The average caloric, carbohydrate, protein and lipid intake was higher than recommendations, and fiber and calcium intake was lower than recommended by the Institute of Medicine; 91.7% of patients in post-oncological treatment were ingesting calcium below the recommendations for their age, in addition to fiber (95.8%), iron (66.7%) and potassium (100%) below those recommended by DRI according with sex and age. Table 2 presents the characteristics of food intake of the individuals evaluated.

A positive and moderate correlation was observed between WC values and calorie intake (r = 0.411, p = 0.046) and iron intake (r = 0.407, p = 0.049). Dietary intake did not correlate with WHtR and disease remission time, as well as with other variables. Table 3 shows the correlations between dietary intake variables, disease remission time and anthropometric indices that predict increased cardiovascular risk.

**Table 2 -** Food intake of children and adolescents after cancer treatment (Aracaju-SE. 2015).

| Nutrients | Overall (n = 24) | Children (n = 11) | Adolescents (n = 13) | Requirements |
|---|---|---|---|---|
| **Calorie (kcal/day)** | 1658.2 ± 258.4 | 1605.0 ± 284.3 | 1703.2 ± 236.2 | - |
| **Carbohydrate (g)** | 176.9 ± 29.9 | 17.,0 ± 37.2 | 182.0 ± 2.3 | 100 g/day |
| **Lipid (g)** | 77.4 ± 17.6 | 75.1 ± 18.4 | 79.3 ± 17.4 | ND |
| **Protein (g)** | 66.3 ± 12.9 | 70.1 ± 12.1 | 63.1 ± 13.2 | 5 – 8 years old: 19 g/day<br>9 – 13 years old: 34 g/day<br>14 – 18 years old:<br>Boys: 52 g/day<br>Girls: 46 g/day |
| **Protein (g/kg weight/day)** | 1.7 ± 0.8 | 2.4 ± 0.6 | 1.1 ± 0.3 | - |
| **Fiber (g/day)** | 16.3 ± 4.6 | 17.5 ± 5.4 | 15.3 ± 3.7 | 5 – 8 years old: 25 g/day<br>9 – 13 years old:<br>Boys: 31 g/day<br>Girls: 26 g/day<br>14 – 18 years old:<br>Boys: 38 g/day<br>Girls: 26 g/day |
| **Calcium (mg/day)** | 795.3 ± 184.4 | 742.4 ± 185.5 | 840.1 ± 178.1 | 4 to 8 years old: 1000 mg/day<br>9 to 13 years old: 1300 mg/day<br>14 to 18 years old: 1300 mg/day |
| **Iron (mg/day)** | 8.8 ± 2.4 | 8.0 ± 2.2 | 9.4 ± 2.4 | 4 a 8 anos: 10 mg/dia<br>9 a 13 anos: 8 mg/dia<br>14 a 18 anos:<br>Meninos: 11 mg/dia<br>Meninas: 15 mg/dia |
| **Potassium (g/day)** | 0.9 ± 0.2 | 0.8 ± 0.2 | 0.9 ± 0.2 | 4 to 8 years old: 2.3 g/day<br>9 to 13 years old:<br>Boys: 2.5 g/day<br>Girls: 2.3 g/day<br>14 to 18 years old:<br>Boys: 3.0 g /day<br>Girls: 2.3 g/day |

Data are presented as mean and standard deviation (SD). Abbreviations: ND: Not determined.

**Table 3 -** Correlation between dietary intake. cancer remission time and anthropometric variables that predict cardiovascular risk in children and adolescents post-cancer treatment.

| Variable | Age (years)¥ | | Height cm)¥ | | Weight (kg) | | BMI (kg/m²) | | WC (cm) | | WHtR | | Cancer remission time (months) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | r | P-value | r | P-value | r | P-value | r | P-value | r | P-value | r | P-value | r | P-value |
| Calorie (kcal/day) | 0.287 | 0.174 | 0.303 | 0.150 | 0.375 | 0.071 | 0.324 | 0.122 | **0.411** | **0.046*** | 0.205 | 0.336 | -0.073 | 0.735 |
| PTN (g/day) | -0.161 | 0.452 | -0.068 | 0.753 | -0.147 | 0.494 | -0.139 | 0.517 | -0.016 | 0.940 | 0.050 | 0.816 | -0.079 | 0.714 |
| CHO (g/day)¥ | 0.161 | 0.452 | 0.286 | 0.176 | 0.150 | 0.583 | -0.014 | 0.947 | 0.202 | 0.344 | 0.020 | 0.924 | -0.122 | 0.602 |
| LIP (g/day) | 0.358 | 0.086 | 0.356 | 0.088 | 0.285 | 0.177 | 0.216 | 0.310 | 0.276 | 0.192 | 0.037 | 0.862 | -0.103 | 0.634 |
| Fiber (g/day) | -0.256 | 0.227 | -0.104 | 0.628 | -0.168 | 0.433 | -0.264 | 0.212 | -0.121 | 0.573 | -0.027 | 0.900 | -0.180 | 0.401 |
| Iron (mg/day) | 0.251 | 0.237 | 0.189 | 0.376 | 0.350 | 0.094 | 0.378 | 0.069 | **0.407** | **0.049*** | 0.140 | 0.514 | -0.310 | 0.141 |
| Calcium (mg/day)¥ | 0.118 | 0.583 | 0.098 | 0.648 | 0.192 | 0.369 | 0.270 | 0.202 | 0.122 | 0.570 | -0.108 | 0.614 | 0.012 | 0.954 |
| Potassium (mg/day) | -0.076 | 0.723 | 0.088 | 0.681 | 0.103 | 0.630 | 0.019 | 0.929 | 0.125 | 0.561 | 0.001 | 0.965 | 0.042 | 0.845 |

*Significant P<0.05; Pearson Correlation Test; ¥Spearman correlation.
Caption: r, correlation coefficient; BMI, body mass index; WC, waist circumference; WHtR, waist-to-height ratio; PTN, protein; CHO, carbohydrates; LIP, lipids.

## DISCUSSION

Excess body weight, accumulation of fat in the abdominal region and increased risk of cardiovascular disease were observed in children and adolescents following cancer treatment in the present study. Daily energy intake contributed to the increase in WC, characterized by the intake of carbohydrates, proteins and lipids above those recommended by the DRI. However, it was not possible to establish a correlation between the predictive indices of increased cardiovascular risk with the time of cancer remission in children after treatment of the disease, showing a greater relationship between the increased cardiovascular risk in children after cancer treatment and habits of life. It should be noted that these results are part of a non-probabilistic sample and the sample size does not allow extrapolation of the data.

With the improvement of therapies applied to cancer treatment, the survival rate of patients with childhood cancer has increased[3,15]. As a consequence, complications resulting from treatment began to occur more significantly[4]. Obesity is among the most frequent complications after cancer treatment, associated with the use of high doses of corticosteroids, unhealthy food choices and reduced physical activity[2,4,16]. Similar to our findings, excess weight was observed in 38.8%[17] and 38.2%[18] of Acute Lymphoid Leukemia (ALL) survivors. In our study, it was ensured that corticosteroids had not been used for at least six months before the evaluation, which shows excess weight and fat accumulation in the abdominal region in children and adolescents after cancer treatment regardless of the use of this type of medication.

In the present study, a moderate and direct correlation was observed between the

calories consumed daily and the increase in WC. Furthermore, despite adequate intake of the evaluated macronutrients, the average daily fiber intake was lower than recommended by the Institute of Medicine. The association between inadequate fiber intake and increased body weight has already been observed and is explained, among other factors, by the role of fiber in controlling the intestinal absorption of fats, in managing intestinal transit control and in modulating the intestinal microbiota, in addition to contributing to satiety[19].

The eating habits of children and adolescents under the age of 18 were evaluated in a systematic review that included cohort and observational studies carried out in European, American and Asian countries, observing that Western eating patterns called snack diets, protein/ fiber and those based on sweets increased the chance of children and adolescents being overweight and/or obese[20]. Furthermore, analyzing data from the China Health and Nutrition Survey (CHNS), three dietary patterns were identified in children and adolescents, categorized into modern and traditional patterns from the north and south, in which the highest quartile of the traditional pattern characterized by milk, fast food, eggs, other meat, poultry and cakes and adopted mainly by younger children and residents in urban areas was associated with overweight and obesity, being explained by the higher intake of calories, carbohydrates, proteins, lipids, fiber, vitamin C, vitamin A, calcium, iron, in the same quartile of the standard, when compared to the other quartiles[21].

Iron intake in the evaluated population correlated with higher WC. One of the explanations for the relationship between iron and obesity/overweight is due to the interaction between adipose tissue metabolism and iron regulation, as this mineral acts in the regulation of lipid and glucose metabolism[22,23]. Changes in the metabolism of these nutrients can contribute to the accumulation of fat in the abdominal regionl[22,23]. Most studies do not relate iron intake with markers of cardiovascular risk, but rather indicators of circulating iron status with variables of cardiometabolic risk, especially when the concentration of this mineral is high in the circulation[24,25]. It should be noted that the public evaluated in the studies is different from that evaluated in this work.

Studies that evaluated the dietary intake of children and adolescents post-cancer treatment are scarce in the literature, however, the results reported in this study are corroborated by a study carried out in Brazil that showed excessive consumption of energy-dense foods, rich in fat, simple sugars and reduced consumption of fiber-rich foods in children and adolescents with cancer[26]. Complementing the finding, inadequate lifestyle habits such as prolonged exposure to screens, sedentary lifestyle and increased fat intake to the detriment of micronutrient intake were also observed in children with cancer, which increases the percentage of fat mass in this population[16]. Furthermore, it was observed that the children and adolescents evaluated had adequate height despite being overweight for their age, contrary to findings in other studies that showed children with short stature and excess body weight[27-29].

In our study, no correlation was found between the time of disease remission and increased cardiovascular risk, however, a high prevalence of children and adolescents with high waist circumference and WHtR was observed, which denotes an increased risk for cardiovascular diseases. Additionally, daily energy intake was positively correlated with the WC of the po-

pulation evaluated, showing the role of food in increasing cardiovascular risk in this population. It is worth mentioning that the indices used to assess cardiovascular risk reflect the accumulation of fat in the abdominal region and present good performance for assessing cardiovascular risk[30], and the findings reported in our study are also in line with those found by Oliveira et al.[28], who observed 16.1% and 35.5% of abdominal obesity in cancer patients when evaluated by WC and WHtR, respectively.

In addition to lifestyle characteristics such as dietary intake and sedentary lifestyle contributing to obesity, patients undergoing cancer post-treatment, specifically, the type of treatment can contribute to the accumulation of body fat in these patients[4]. Furthermore, corticosteroids used in treatment also play an important role in regulating energy intake, storage and mobilization[31].

Therefore, considering that factors such as the type of treatment and type of cancer contribute to obesity and increase the cardiovascular risk of children and adolescents, modifiable factors such as eating habits and physical exercise need to be considered as contributors to the reduction of obesity and cardiovascular risk in this population.

The limitations of this study include the number of participants, which may reduce statistical power, in addition to the lack of information about the medications used during cancer treatment, including dose and duration of use. However, the study provides results that highlight the importance of carrying out prospective studies that evaluate the effects of cancer treatment on excess weight after treatment at different time intervals (short, medium and long term), taking into account food consumption. as one of the factors associated with the development of obesity and related comorbidities.

## CONCLUSION

The study showed a high prevalence of overweight or obesity, as well as cardiovascular risk, assessed by anthropometric indicators that reflect cardiometabolic risk. The intake of fiber, calcium, iron and potassium was below recommended in most of the patients evaluated. The time after disease remission did not correlate with the variables of nutrient intake and markers of cardiovascular risk in children and adolescents after cancer treatment. Despite the reduced iron intake, the amount of iron consumed correlated positively with WC. Likewise, calorie consumption was also correlated with WC.

Therefore, our results highlight the importance of evaluating and monitoring the nutritional status of children and adolescents who have undergone cancer treatment, given the potential of this type of treatment to promote endocrine and metabolic changes, thus increasing cardiovascular risk in this population.

**CRediT author statement**

Conceptualization: Pires, LV; Oliveira, MBB. Methodology: Oliveira, MBB; Melo, MWL; Pires, LV. Statistical analysis: Santos, RKF; Pires, LV. Formal analysis: Oliveira, MBB. Investigation: Oliveira, MBB; Melo, MWL. Preparation of the original draft: Oliveira, MBB. Review and editing of the writing: Santos, KF; Pires, LV; Barbosa, KBF. Supervision: Pires, LV; Barbosa, KBF.

All authors have read and agreed with the published version of the manuscript.

# REFERENCES

1. Cancer facts and figures 2020 [Internet]. [cited 2023 Oct 17]. Available from: https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/annual-cancer-facts-and-figures/2020/cancer-facts-and-figures-2020.pdf

2. Gebauer J, Higham C, Langer T, Denzer C, Brabant G. Long-Term Endocrine and Metabolic Consequences of Cancer Treatment: A Systematic Review. Endocr Rev. 2019;40(3):711–67. DOI: 10.1210/er.2018-00092

3. York JM. Generously supported by with special appreciation to Long-Term Follow-Up Guidelines for Survivors of Childhood, Adolescent, and Young Adult Cancers [Internet]. 2018. Available from: www.survivorshipguidelines.org

4. Zhang FF, Kelly MJ, Saltzman E, Must A, Roberts SB, Parsons SK. Obesity in pediatric ALL survivors: a meta-analysis. Pediatrics. 2014;133(3):704-15. doi: 10.1542/peds.2013-3332.

5. Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Orientações para a coleta e análise de dados antropométricos em serviços de saúde: Norma Técnica do Sistema de Vigilância Alimentar e Nutricional - SISVAN / Ministério da Saúde, Secretaria de Atenção à Saúde, Departamento de Atenção Básica. Ministério da Saúde. 2011. 76 p.

6. World Health Organization. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development [Internet]. [cited 2023 Oct 17]. Available from: https://www.who.int/publications/i/item/924154693X

7. Maffeis C, Banzato C, Talamini G. Waist-to-Height Ratio, a Useful Index to Identify High Metabolic Risk in Overweight Children. J Pediatr. 2008;152(2):207-213.e2. DOI: 10.1016/j.jpeds.2007.09.021

8. Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. Int J Food Sci Nutr. 2005;56(5):303–7. DOI: 10.1080/09637480500195066

9. Freedman DS, Serdula MK, Srinivasan SR, Berenson GS. Relation of circumferences and skinfold thicknesses to lipid and insulin concentrations in children and adolescents: the Bogalusa Heart Study. Am J Clin Nutr. 1999;69(2):308–17. DOI: 10.1093/ajcn/69.2.308

10. Institute of Medicine. 2006. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. Washington, DC: The National Academies Press. https://doi.org/10.17226/11537

11. Institute of Medicine. 2005. Food and Nutrition Board. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients). National Academy Press.

12. Institute of Medicine (US) Committee to Review Dietary Reference Intakes for Vitamin D and Calcium; Ross AC, Taylor CL, Yaktine AL, et al., editors. Washington (DC): National Academies

13. National Academies of Sciences, Engineering, and Medicine. 2019. Dietary Reference Intakes for Sodium and Potassium. Washington, DC: The National Academies Press. https://doi.org/10.17226/14.

14. Cohen J. Statistical Power Analysis for the Behavioral Sciences [Internet]. Routledge; 2013. Available from: https://www.taylorfrancis.com/books/9781134742707

15. Steliarova-Foucher E, Colombet M, Ries LAG, Moreno F, Dolya A, Bray F, Hesseling P, Shin HY, Stiller CA; IICC-3 contributors. International incidence of childhood cancer, 2001-10: a population-based registry study. Lancet Oncol. 2017: 18(6):719-731. doi: 10.1016/S1470-2045(17)30186-9.

16. Murphy-Alford AJ, White M, Lockwood L, Hallahan A, Davies PSW. Body composition, dietary intake and physical activity of young survivors of childhood cancer. Clinical Nutrition. 2019;38(2):842–7. DOI: 10.1016/j.clnu.2018.02.020

17. Veringa SJE, van Dulmen den Broeder E, Kaspers GJL, Veening MA. Blood pressure and body composition in long term survivors of childhood acute lymphoblastic leukemia. Pediatr Blood Cancer. 2012;58(2):278–82. DOI: 10.1002/pbc.23251

18. Chow EJ, Pihoker C, Hunt K, Wilkinson K, Friedman DL. Obesity and hypertension among children after treatment for acute lymphoblastic leukemia. Cancer. 2007;110(10):2313–20. DOI: 10.1002/cncr.23050

19. Delzenne NM, Olivares M, Neyrinck AM, Beaumont M, Kjølbæk L, Larsen TM, et al. Nutritional interest of dietary fiber and prebiotics in obesity: Lessons from the MyNewGut consortium. Clinical Nutrition. 2020;39(2):414–24. DOI: 10.1016/j.clnu.2019.03.002

20. Liberali R, Kupek E, Assis MAA De. Dietary Patterns and Childhood Obesity Risk: A Systematic Review. Childhood Obesity. 2020;16(2):70–85. DOI: 10.1089/chi.2019.0059

21. Zhang J, Wang H, Wang Y, Xue H, Wang Z, Du W, et al. Dietary patterns and their associations with childhood obesity in China. British Journal of Nutrition. 2015;113(12):1978–84. DOI: 10.1038/ejcn.2015.8

22. Hilton C, Sabaratnam R, Drakesmith H, Karpe F. Iron, glucose and fat metabolism and obesity: an intertwined relationship. Int J Obes (Lond). 2023;47(7):554-563. doi: 10.1038/s41366-023-01299-0.

23. Alshwaiyat NM, Ahmad A, Wan Hassan WMR, Al-Jamal HAN. Association between obesity and iron deficiency (Review). Exp Ther Med. 2021;22(5):1268. doi: 10.3892/etm.2021.10703.

24. Panichsillaphakit E, Suteerojntrakool O, Pancharoen C, Nuchprayoon I, Chomtho S. The Association between Hepcidin and Iron Status in Children and Adolescents with Obesity. J Nutr Metab. 2021; 2021:9944035.

25. Suárez-Ortegón MF, Prats-Puig A, Bassols J, Carreras-Badosa G, McLachlan S, Wild SH, López-Bermejo A, Fernández-Real JM. Iron status and cardiometabolic risk in children. Diabetes Res Clin Pract. 2023;202:110795. doi: 10.1016/j.diabres.2023.110795.

26. Nunes MMA, Figueiro JN, Alves JGB. Excesso de peso, atividade física e hábitos alimentares entre adolescentes de diferentes classes econômicas em Campina Grande (PB). Rev Assoc Med Bras. 2007;53(2). DOI: 10.1590/S0104-42302007000200017

27. Kuperman H, Battistin C, Moreira ACF, Cornacchioni AL, Odone Filho V, Setian N, et al. Avaliação dos principais efeitos endócrinos tardios em crianças e adolescentes sobreviventes ao tratamento de neoplasias malignas. Arq Bras Endocrinol Metabol. 2010;54(9):819–25. DOI: 10.1590/S0004-27302010000900008

28. Oliveira BA de, Lins MM, Pedrosa F, Cabral PC, Barbosa JM. Estado nutricional de crianças e adolescentes sobreviventes de leucemia linfoide aguda tratados em um Centro de Referência da Região Nordeste do Brasil. Revista de Nutrição. 2013;26(3):271–81. DOI: 10.1590/S1415-52732013000300002

29. Couto-Silva AC, Brauner R, Adan LF. Seqüelas endócrinas da radioterapia no tratamento do câncer na infância e adolescência. Arq Bras Endocrinol Metabol. 2005;49(5):825–32. DOI: 10.1590/S0004-27302005000500025

30. Chiara VL, Silva HGV da, Barros ME, Rêgo AL, Ferreira AL, Pitasi BA, et al. Correlação e concordância entre indicadores de obesidade central e índice de massa corporal em adolescentes. Revista Brasileira de Epidemiologia. 2009;12(3):368–77.

31. Zhang FF, Kelly MJ, Saltzman E, Must A, Roberts SB, Parsons SK. Obesity in Pediatric ALL Survivors: A Meta-Analysis. Pediatrics. 2014;133(3):e704–15. DOI: 10.1542/peds.2013-3332